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RADIATION SAFETY MANUAL FOR SANITARY ENGINEERING CENTER ACTIVITIES

George I. Coats

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1959

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RADIATION SAFETY MANUAL

FOR SANITARY ENGINEERING CENTER ACTIVITIES

George I. Coats, Assistant Sanitarian (R)

Radiation Safety Officer

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE

Public Health Service
Bureau of State Services
Division of Radiological Health

Robert A. Taft Sanitary Engineering Center
Cincinnati 26, Ohio

1959

I

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FOREWORD

This Manual is a comprehensive compilation of current radiological safety practices. Although written specifically for use at the Robert A. Taft Engineering Center, the principles involved may be applicable to other facilities in which radioactive materials are used.

It is our sincere hope that the Manual will serve as a valuable guide toward the effective management of the ever-occurring problems in the field of radiation safety.

Francis J. Weber, Chief
Division of Radiological Health

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I. ORGANIZATION

A. RADIATION SAFETY AND ISOTOPES COMMITTEE (RSIC)

The control of radionuclides and radiation safety at the Robert A. Taft Sanitary Engineering Center is the concern of the Radiation Safety and Isotopes Committee, which is a subcommittee of the Center's Safety Committee.

The Radiation Safety and Isotopes Committee (RSIC) is composed of one representative from each program at the Center, as each program uses radionuclides in some form. One representative is chosen as chairman of the committee. The committee is required by the Atomic Energy Commission as a licensing requirement and is authorized by the Director of the Center.

B. RADIATION SAFETY OFFICER (RSO)

The RSIC designates a Radiation Safety Officer (RSO) who is a member of the RSIC and is responsible to the committee for the execution of its policies. An alternate is designated as acting RSO during any absence of the RSO.

The duties of the RSO shall include the following:

1. Supervising and providing personnel and laboratory monitoring for the Center.
2. Directing the safe handling of radionuclides. This shall include procurement, transportation, storage, monitoring, use, and disposal of radioactive materials.
3. Maintaining records. These shall include personnel exposure records, a log of all activities of the RSO, and records of receipt, storage, use, and disposal of all radionuclides.
4. Membership in the Center Safety Committee.

II. RADIONUCLIDES

A. LICENSING

The Center holds a byproduct license from the U. S. Atomic Energy Commission. This license specifies the quantities of materials the Center may have, the authorized uses, and the precautions for protection of health and safety which are required.

See Appendixes I & J

See Appendixes I & J for licensing requirements, compulsory conditions of the license, and standards for protection.

B. PROCUREMENT

The procedure for the procurement of radionuclides is:

1. All requests for radionuclides must be discussed beforehand with the RSO and the RSIC Program representative concerned. At this time, the method of handling, storage, monitoring, disposal, and all other safety precautions to be observed shall be decided upon. These arrangements shall be recorded by the procuror in a written memorandum to the RSO for his files.
2. The purchase requisition must be signed by RSO and the Chairman of the RSIC indicating their approval. A copy of the purchase requisition shall be provided for the radionuclide log. Such approval is required by the AEC under our byproduct license.
3. All radioisotopes entering the Center shall be delivered to the RSO who will, in turn, notify the purchaser. Radionuclides must be stored in clearly marked areas, designated as storage area, by the RSO.

C. STORAGE

Radioactive materials must be stored so that the background in inhabited areas is less than 1 mr/hr. If additional storage space is needed, arrangements must be made with the RSO.

D. USE

See Appendix A

It is the policy of the RSIC to encourage the use of radionuclides where considerations of safety, cost, and convenience do not prohibit their use. The amount needed and the relative hazard of a particular radionuclide dictate how and where it will be used. Included as Appendix A is a chart showing the relative hazards of the principal radionuclides used in the laboratory. This information should be considered when planning any operation involving the use of radioactive materials.

E. DISPOSAL

Radionuclides at the Center are disposed of in the following manner:

1. Decay

   If the radionuclide is shortlived it may be stored until the activity has decayed. This method becomes impractical if the half-life is greater than 30 days.

2. Sewer Disposal

See Appendix H

   If the radionuclide is water soluble, it may be flushed down the drain providing the activity is below maximum permissible levels. See Appendix H for maximum permissible levels and procedures for disposal by sewer. If a liquid waste cannot be disposed of by the sewer method, it may be precipitated or evaporated and treated as a solid waste.

3. Solid Wastes

   Solid wastes are stored in steel drums to be shipped to a disposal agency. The laboratories which produce solid wastes should provide themselves with a radioactive waste can. This can must be clearly labeled and should be painted yellow. It must have a cover which is kept in place and must be lined with a disposable plastic

bag obtainable from the RSO. When full, a request is made to the RSO for disposal. He will empty the cans. The RSO has a waste disposal request form (SEC-57) which must be filled out by the person requesting disposal. This is to assist the RSO in recording how and where all radionuclides are disposed. This form must also be completed for disposing of radionuclides by sewer.

III. HAZARDS

Health hazards from radionuclides are of two types -- external and internal.

A. EXTERNAL

The external hazard arises from the exposure of a portion or the entire body of beta or gamma radiation. External radiation is easily measured and controlled. While the Center does have several small neutron sources, no routing exposure to neutrons is expected. Because of the difficulty of instrumentation of neutrons, the neutron sources must be used under the direct control and supervision of the RSO.

Since they are so easily stopped by the outer layer of the skin, alpha sources ordinarily are not considered external hazards.

B. INTERNAL

Perhaps the more serious radiation hazard at the Center arises from the deposition of radionuclides in the body. Deposition may result from ingestion, inhalation, or absorption through the skin or injured body surfaces. This hazard is magnified because of the difficulty in detecting the radionuclides within the body. Once the radionuclide is in the body, little can be done to reduce the exposure. (Induce immediate vomiting if accidently ingested.) Also, the ionizing effects are much greater when the radioisotope is in the body in direct contact with the critical organs. For example, alpha particles are relatively harmless as viewed from external considerations, but they are extremely dangerous as internal radiators. Their relative biological effect may be 20 times that of beta or gamma emitters in the body.

IV. PROTECTIVE MEASURES

A. EXTERNAL

1. Time, 2. Distance, 3. Shielding

The basic protective measures to reduce external radiation are time, distance, and shielding. In every situation these three factors must be considered jointly. While shielding is desirable in reducing the exposure, it must not be overlooked that doing the job in one-half the time is just as effective as halving the radiation flux with shielding. Working twice as far from a point source is as effective as doing the job in one-fourth the time. Continuous use of monitoring equipment is the best method of evaluating the hazard and reducing the exposure. Every user of radioisotopes should have at hand adequate survey instruments to keep check on his operations. See Appendix C on characteristics and use of common survey instruments.

B. INTERNAL

The prevention of internal exposure is more exacting and less easily performed. The maximum permissible levels of radioactive contamination in the air or on laboratory surfaces is of such a low level that it cannot be detected with ordinary survey instruments. Appendix B Contamination See Appendix B on contamination and Appendix E Laboratory Monitoring Appendix E on smear method of laboratory monitoring.

The general policy in the use of radionuclides is to use such equipment and procedures which will most reduce the probability of getting radionuclides into the body. Outlined below are rules and procedures for this purpose. These rules are for amounts and hazards greater than those ordinarily encountered in low level environ-

mental samples and tracer work. More rigid regulations will be required for high level work.

1. Protective Clothing

   A laboratory coat should be worn when working with radioactive materials. Where necessary, rubber gloves, safety glasses, and shoe covers should be worn. These items should not be worn outside the laboratory, i.e., offices, counting rooms, rest rooms, etc. Never wear laboratory coats to the cafeteria. Monitor clothing before it is returned to the laundry. The RSO will provide protective clothing when possible; otherwise, the items must be purchased by the program using them.

2. Laboratory Equipment and Design

   The experiment should be designed with recognition of the radiation hazards involved. The equipment should be such that the damage is minimal if the worst should happen. When designing for radioactive work, attention must be given to hoods, drains, ventilation, traffic, etc.

3. Handling Procedures

   To reduce the risk of spills to a minimum:

   a. Use double containers for radionuclides.
   b. Use protective covering and lids.
   c. Use unbreakable containers to store radioisotopes.
   d. Use extreme caution in transfers -- try a dummy run to test the procedure.
   e. Use hoods for transfers and dilutions.
   f. Use a dry box for dusty materials and operations.
   g. Do not pipette by mouth. Use rubber bulbs, syringes, or pipettors.
   h. Always plan the procedure to be used. Know what you are going to do before you do it.
   i. Use absorbent paper to cover the working area to absorb the radioactive material in the event of a spill.

4. Goodhousekeeping Habits

   Much of the job of preventing the spread of contamination is a matter of good housekeeping

   a. Keep the laboratory neat and clean. Keep the work area free of equipment and materials not required for the immediate procedure.

b. Wash hands and arms thoroughly before handling any object which goes to the mouth, nose, or eyes. Wash the hands whenever leaving the laboratory after handling radioactive materials, e.g., before taking sample to counting room. Monitor the hands whenever contamination is suspected and decontaminate immediately.

c. Keep fingernails short and clean. Do not work with radioactive materials if there is a break in the skin below the wrist unless the wound is so protected that radioactive materials cannot gain access to the body. Cover the break with tape (plastic or adhesive) and wear a rubber glove.

d. No smoking or eating is allowed in the radionuclide laboratories. This includes gum, candy, and beverages. Food containers are not permitted in the laboratories. Refrigerators shall not be used jointly for foods and radioactive materials.

5. Personnel Monitoring

Each person is responsible for monitoring his person, clothing, shoes, and laboratory equipment which may be contaminated. Monitoring shall be mandatory before leaving the work areas for lunch or at the end of the day.

V. INSTRUMENTATION

A. PERSONNEL METERING

The basic personnel metering system at the Center is as follows:

1. Film Badges

Any person who has a probability of being exposed to significant amounts of external radiation is issued a lapel film badge by the RSO. The film is developed periodically and the results are kept on file with the RSO. The readings will be furnished to individuals when there is a noticeable reading or upon request. Finger ring film dosimeters and wrist film badges are available as needed.

Film badges will be furnished to all visitors and training classes that work with radioactive materials.

2. Pocket Dosimeters

The radiation safety office will supply pocket dosimeter service to anyone requiring such. Personnel working with any source of radiation. where a daily exposure of more than 10 millirem is possible must wear pocket chambers. Two chambers should be worn in event of the failure of one chamber. As a rule of thumb, if the radiation levels exceed 20 mr/hr at any point, pocket chambers are called for.

3. Survey Meters

Every radionuclide laboratory must have a working survey-meter. This will usually be of the Geiger-Mueller type. This instrument is for the use of personnel in the laboratories to check for contamination and is suitable for such routine uses as:

a. Checking laboratory surfaces, glassware, and tools for beta-gamma contamination.
b. Checking hands, shoes, and clothing.

c. Measuring the radiation level from low level sources (less than 20 mr/hr).

See Appendix C on Survey Meters

The Geiger-Mueller type meter has serious limitations which must be understood before the instrument can successfully be used as a monitoring device. See Appendix C on G-M Survey Instruments.

High level beta-gamma meters, alpha meters, alpha-beta-gamma scintillation meters, and a neutron meter are also available. Arrangements must be made with the RSO for suitable instruments before doing isotope work.

B. LABORATORY MONITORING

Appendix G Air Sampling

Appendix B Contamination

Appendix C Survey Meters

Periodic monitoring of the radioisotope laboratories will be conducted by the RSO. This should in no way detract from the routing day to day monitoring by the personnel working in the laboratories. The RSO shall have a floor plan of each laboratory which uses radioisotopes. During the periodic checkup, the RSO will record on this floor plan all smear counts, instrument readings, and any other pertinent information.

The RSO will direct any changes or decontamination necessary and the personnel involed are responsible for the required action. If not complied with, action will be taken with the program chief through the RSIC member. The RSO will do the special monitoring jobs such as air sampling and checking hoods and drains prior to repair.

C. PERMISSIBLE EXPOSURES

See Appendix B for MPL of Laboratory Contamination

The maximum permissible external exposure shall be taken to be 100 millirem per week as suggested by the supplement to NBS Handbook 59 The maximum permissible concentrations of radionuclides in air and water are chosen in accord with Handbook 69 or its successor. In the table on decontamination (Appendix B) permissible levels of contamination are suggested for use at the Center.

VI. DECONTAMINATION PROCEDURES

Because there is no extensive list of procedures for decontamination, an appendix of decontaminating agents and suggested procedures is included (Appendix B).

Included is a list of maximum permissible levels of surface contamination for use at the Center. It must be recognized that these are arbitrary values. The figures are on the conservative side, however, and if followed, no over-exposure should be experienced even from the most hazardous radionuclides.

A. PRIMARY CONSIDERATIONS

1. Prevent Spread of Contamination

The RSO should be called for assistance as soon as possible whenever a spill occurs. The first consideration after personnel safety is to decontaminate. Many factors must be considered, including tracking by persons, movement by air currents (hoods, fans, etc.), water, dusting, mopping, and other physical actions. To confine it, decontaminate the spill from the outside toward the center.

2. Make a Plan

Successful decontamination calls for planned action. A spur of the moment action or attempt at decontamination can cause more harm than good. Perhaps the best thing to do after a spill is to go sit in front of the laboratory door and make a thorough plan of the steps to be taken in the decontamination procedure.

3. Monitoring

Make full use of instruments and available assistance. Each step of the decontamination should be monitored. One person should be kept clean to operate the instruments and do other monitoring. When the instruments become con-

taminated any progress is hopeless. Protective clothing, footwear, gloves, and assult masks should be used as needed.

4. Records

Complete records should be made of each action. Copies should be sent to the RSO and RSIC. In most cases the RSO will be involved so a joint report can be filed. This report is necessary, among other reasons, because the AEC requires a report of any major incident. See Appendix J, Federal Register.

5. Waste Disposal

Provisions must be made for disposal of cleaning solutions and contaminated articles. In some instances, it may be judged better to dispose of a contaminated article than to attempt to decontaminate it.

B. DECONTAMINATION PROCEDURES

Located in Appendix B.

VII. RADIATION PRODUCING MACHINES

Listed below are recommendations for the use of the radiation producing machines at the Center.

1. The RSO shall be notified prior to the use of any radiation producing machine at the Center. At this time, arrangements must be made concerning monitoring equipment and other necessary safety precautions.
2. The radiation producing machines at the Center shall be operated only by qualified personnel.
3. When operating an x-ray machine, the operator must have at hand a suitable monitoring instrument. A cutie-pie is recommended. Film badges and pocket chambers must be worn.
4. Radiation warning signs must be placed so as to prevent personnel from entering the radiation area. Remove the signs when there is no longer any need for them. In certain instances, other precautions, such as locking the entrances to the room, may be advised by the RSO.
5. The operator must never expose himself to the direct beam of an x-ray machine and must not stand within 4 feet of the tube or irradiated target while the machine is in operation unless adequately shielded.
6. Make allowances for the range of the x-rays. For example, when the beam is directed across the room, the radiation will extend into adjoining rooms. Make full use of protective barriers, lead aprons, and gloves.
7. Observe any restrictions on the use of the machines recommended by the RSIC.

VIII. PROCEDURES FOR RADIOACTIVE SPILLS

Emergencies will generally be in the nature of spills, fires, or explosions as a result of which radioactive materials are spread around the laboratory. Emergency procedures adopted from National Bureau of Standards Handbook 48 are given here as a guide. It must be recognized that these procedures are general and any specific emergency will call for further adaptations and changes in procedure.

A. MINOR SPILLS INVOLVING NO RADIATION HAZARD TO PERSONNEL

1. Notify all other persons in the room at once.
2. Permit only the minimum number of persons necessary to deal with the spill into the area.
3. Confine the spill immediately.
   Liquid Spills:
   Don protective gloves
   Drop absorbent paper on spill.
   Dry Spills:
   Don protective gloves.
   Dampen thoroughly, taking care not to spread the contamination. Water may generally be used except where chemical reaction with the water would generate an air contaminant. Oil should then be used.
4. Decontaminate. Make a plan first.
5. Monitor all persons involved in the spill and clean up operations.
6. A complete history of the accident and subsequent remedial or protective measures must be submitted to the RSIC and RSO.

B. MAJOR SPILLS INVOLVING RADIATION HAZARD TO PERSONNEL

1. Notify all persons not involved in the spill to

vacate the room at once. Limit the movement of displaced persons to confine the spread of contamination.

2. If the spill is liquid and the hands are protected, right the container, otherwise use a stick or lever.
3. If the spill is on the skin, flush thoroughly.
4. If the spill is on clothing, discard outer or protective clothing at once.
5. Switch off all fans.
6. Vacate the room.
7. Notify the RSO as soon as possible.
8. Take immediate steps to decontaminate personnel involved, as necessary.
9. Decontaminate the area. (Personnel involved in decontamination must be adequately protected.) The RSO will direct the decontamination.
10. Monitor all persons involved in the spill and cleaning.
11. Permit no person to resume work in the area without the approval of the RSO.
12. A complete history of the accident and subsequent activity must be submitted to the RSIC and RSO.

C. ACCIDENTS INVOLVING RADIOACTIVE DUSTS, MISTS, FUMES, ORGANIC VAPORS, and GASES

1. Notify all other persons to vacate the room immediately.
2. Hold breath and close escape valves.
3. Vacate the room.
4. Notify the RSO at once.
5. Ascertain that all doors giving access to the room are closed. Post conspicuous warnings or guards to prevent accidental opening of doors.

Note: Masks are located in the red boxes in the halls.

6. Monitor all persons suspected of contamination. Proceed with decontamination of personnel.
7. Report at once all known or suspected inhalations of radioactive materials.
8. Evaluate the hazard and the necessary safety devices for safe re-entry.
9. Determine the cause of contamination and rectify the condition.

10. Decontaminate the area.
11. Perform air survey of the area before permitting work to be resumed.
12. Submit a complete history of the accident and subsequent activities for the RSO and RSIC.

D. INJURIES TO PERSONNEL INVOLVING RADIATION HAZARD

1. Wash minor wounds immediately under running water, while spreading the edges of the gash.
2. Report all radiation accidents to personnel (wounds, overexposure, ingestion, inhalation) to the RSO as soon as possible.
3. Call at once a physician qualified to treat radiation injuries.
4. Permit no person involved in a radiation injury to return to work without the approval of the attendant physician and the RSO.
5. Prepare a complete history of the accident and subsequent activity related thereto for the RSO and RSIC.
6. Report to personnel on proper forms for compensation and report to AEC.

E. FIRES OR OTHER MAJOR EMERGENCIES

1. Notify all other persons in the room and building at once.
2. Notify the fire department and other local plant safety personnel and the RSO.
3. Attempt to put out fires if radiation hazard is not immediately present.
4. Govern fire-fighting or other emergency activities by the restrictions of the RSO.
5. Monitor all persons involved in combating the emergency.
6. Following the emergency, monitor the area and determine the protective devices necessary for safe decontamination.
7. Decontaminate. - Follow a plan.
8. Permit no person to return to work without the approval of the RSO.
9. Prepare a complete history of the emergency and subsequent activity related thereto for the RSO and RSIC.

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"Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," Natl. Bur. Standards Handbook 69, June 5, 1959.

APPENDIX A

CLASSIFICATION OF ISOTOPES ACCORDING TO RELATIVE RADIO-TOXICITY

Class A (Very high toxicity): $Sr^{90} + Y^{90}$, Po^{210}, At^{211}, Ra^{226}, Ac^{227}, Pu^{239}, Am^{241}, Cm^{242}, Ra^{228}, Th^{228}, Th^{230}, Th^{232}, Np^{237}, Pu^{238}, Pu^{240}, Pu^{242}, Am^{243}, Cm^{243}, Cm^{244}, Cm^{245}, Cm^{246}, Cf^{249}, Cf^{250}, Cf^{252}.

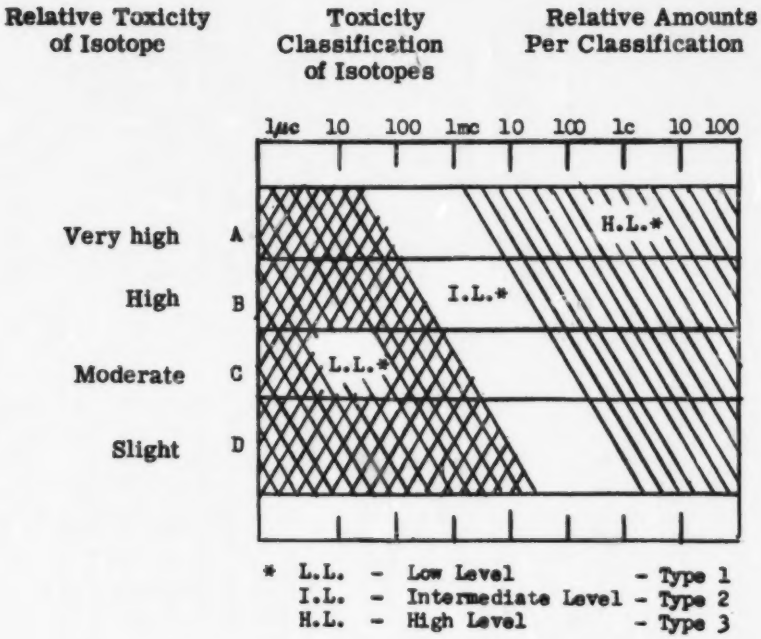
Class B (High toxicity): Ca^{45}, Fe^{59}, Sr^{89}, Y^{91}, Ru^{106}+ Rh^{106}, I^{131}, Ba^{140}+La^{140}, Ce^{144}+Pr^{144}, Sm^{151}, Eu^{154}, Pb^{210}+drs, Th^{234}+Pa^{234}, U^{233}, Ca^{47}, I^{126}, I^{129}, Nd^{144}, Sm^{147}, Eu^{152} (13y), Eu^{155}, Hg^{203}, Pb^{212}, Bi^{206}, Bi^{207}, Bi^{210}, Bi^{212}, Ra^{223}, Ra^{224}, Ac^{228}, Th^{227}, Pa^{230}, U^{230}, U^{234}, U^{235}, U^{236}, U^{238}, Pu^{241}, Bk^{249}.

Class C (Moderate toxicity): Na^{22}, Na^{24}, P^{32}, S^{35}, Cl^{36}, K^{42}, Sc^{46}, Sc^{47}, Sc^{48}, V^{48}, Mn^{52}, Mn^{54}, Mn^{56}, Fe^{55}, Co^{58}, Co^{60}, Ni^{59}, Cu^{64}, Zn^{65}, Ga^{72}, As^{74}, As^{76}, Br^{82}, Rb^{86}, Zr^{95}+Nb^{95}, Nb^{95}, Mo^{99}, Tc^{96}, Rh^{105}, Pd^{103}+Rh^{103}, Ag^{105}, Ag^{111}, Cd^{109}+Ag^{109}, Sn^{113}, Te^{127}, Te^{129}, I^{132}, Cs^{137}+

Ba^{137}, La^{140}, Pr^{143}, Pm^{147}, Ho^{166}, Tm^{170}, Lu^{177}, Ta^{182}, W^{181}, Re^{183}, Ir^{190}, Ir^{192}, Pt^{191}, Pt^{193}, Au^{196}, Au^{198}, Au^{199}, Tl^{200}, Tl^{202}, Tl^{204}, Pb^{203}, A^{31}, Co^{57}, Co^{58m}, Ni^{63}, Ni^{65}, Zn^{69m}, Zn^{69}, As^{73}, As^{77}, Se^{75}, Kr^{85m}, Kr^{85}, Kr^{87}, Rb^{87}, Sr^{91}+Y^{91}, Sr^{92}+Y^{92}, Y^{90}, Y^{90}, Y^{92}, Y^{93}, Zr^{93}, Nb^{93m}, Tc^{97m}, Tc^{97}, Tc^{99}, Ru^{97}, Ru^{103}, Ru^{105}, Pd^{109}+Ag^{109m}, Ag^{110m}, Cd^{115m}, Cd^{115}, In^{114m}, In^{115}, Sn^{125}, Sb^{122}, Sb^{124}, Sb^{125}, Te^{125m}, Te^{127m}, Te^{129m}, Te^{131m}, I^{133}, I^{134}, I^{135}, Xe^{133}, Xe^{135}, Cs^{134}, Cs^{135}, Cs^{136}, Ba^{131}, Ce^{141}, Ce^{143}, Pr^{142}, Nd^{147}, Pm^{149}, Sm^{153}, Eu^{152}, Gd^{153}, Tb^{160}, Dy^{166}, Er^{169}, Tm^{171}, Yb^{175}, Hf^{181}, W^{185}, Re^{186}, Re^{187}, Re^{188}, Os^{185}, Os^{191}, Os^{193}, Ir^{194}, Pt^{193m}, Pt^{197}, Hg^{197m}, Hg^{197}, Rn^{220}, Th^{231}, Pa^{233}, Np^{239}.

Class D (Slight toxicity): H^3, Be^7, C^{14}, F^{18}, Cr^{51}, Ge^{71}, Tl^{201}, Si^{31}, Cl^{38}, A^{37}, Zr^{97}-Nb^{97}, Nb^{97}, Tc^{96m}, Tc^{99m}, Rh^{103m}, In^{113m}, In^{115m}, Cs^{131}, Cs^{134m}, Nd^{149}, Gd^{159}, Dy^{165}, Er^{171}, Os^{191m}, Pt^{197m}.

The chemical form of the isotope may in some cases affect its toxicity.



The activity levels specified above are intended as a general guide and not as rigid regulations. They will be subject to modification according to the skill and experience of the operators and the type of work being done. Suggested mofifying factors are given below.

Modifying factors to be applied to the above quantities, according to the complexity of the procedures to be followed.

Procedure	Modifying Factor
Very simple wet operations (e.g., preparation of aliquotes of stock solutions)	x 10
Normal chemical operations (e.g., analytical procedures, simple chemical separations)	x 1
Complex wet operations (e.g., multiple chemical operations or operations involving complex glass apparatus)	x 0.1
Simple dry operations (e.g., preparation of aliquots or mixing of powders)	x 0.1
Dry and dusty operations (e.g., grinding)	x 0.01

APPENDIX B

DECONTAMINATION PROCEDURES

(Where possible, the preferred decontaminating agent is listed first.)

Contaminated Area	Decontaminating Agent	Remarks	Maximum Permissible Levels of Contamination
Skin & Hands	Mild Soap & Water	Wash 2-3 min. & monitor. Do not wash over 3-4 times.	Alpha 150 d/m/100cm^2
	If necessary, follow by soft brush, heavy lather, and tepid water. Lava Soap & Water	Use light pressure with heavy lather. Wash for 2 min., 3 times. Rinse and monitor. Use care not to scratch or erode skin. Apply lanolin or hand cream to prevent chapping.	This is approx. 1/2 the inhalation level in terms of total dis/min/day. This assumes not more than 1/5 of this material will be inhaled. Additional possible exposure by ingestion is also considered.
	Other Procedures		Beta-Gamma

A mixture of 50% Tide & 50% corn meal.	Make into a paste. Use with additional water with a mild scrubbing action. Use care not to scratch or erode the skin.	Average less than 0.3 mr/hr for each hand surface or 100 cm^2 of skin surface, using GM instrument calibrated with Ra^{226}.
A 5% water solution of a mixture or 30% Tide, 65% Calgon, & 5% Car bose (Carboxymethyl Cellulose)	Use with water. Rub for a minute and rinse.	
A preparation of 8% Carbose, 3% Tide, 1% Versene, & 88% water homogenized into a cream.	Use without any additional water. Rub for 1 min. and wipe off. Follow with lanolin or hand cream	
Chemical Procedures	(As a last resort)	
Titanium dioxide paste	Work the paste into affected area for 2 min. Rinse and wash with soap, brush, and warm water. Monitor.	
Prepare paste by mixing precipitated titanium dioxide		

Contaminated Area	Decontaminating Agent	Remarks	Maximum Permissible Levels of Contamination
	(a very thick slurry never permitted to dry) with a small amount of lanolin.		
	Mix equal volumes of a saturated solution of potassium permanganate and 0.2 N sulfuric acid. Continue with the next step also.	Pour over wet hands, rubbing the surface and using hand brush for not more than 2 min. (Note: will remove a layer of skin if in contact with the skin for more than 2 min.) Rinse with water.	
	Apply a freshly prepared 5% solution of sodium acid sulfite ($NaHSO_3$)	Apply in the same manner as above. Apply for not more than 2 min.	
		The above procedure may be repeated. Apply lanolin or hand cream when completed.	

Wounds (Cuts and breaks in the skin)	Running Tap Water Report to Medical Officer and RSO as soon as possible	Wash the wound with large volumes of running water immediately (within 15 sec.) Spread the edges of wound to permit flushing action by the water	Keep the contamination as low as possible. No MPL can be set.
Ingestion by swallowing	Immediately induce vomiting. Drink large quantities of liquids to dilute the activity.	Urine & fecal analysis will be necessary to determine amount of radionuclides in the body.	
Clothing	Wash - if levels permit.	Use standard laundering procedures, 3% versene or citric acid may be added to wash water. Wash water must be below the MPL for sewer disposal.	Alpha 150 d/m/100cm^2 Beta-Gamma No area to average more than 0.1 mr/hr. GM meter Ra^{226} calibrated.

Contaminated Area	Decontaminating Agent	Remarks	Maximum Permissible Levels of Contamination
See rubber & leather under specific materials	Store	To allow for decay if contamination is short lived.	(If clothing is worn 100 hr/wk this will give 1/10 of maximum external dose.)
	Disposal	Treat as solid waste if necessary.	
Glassware	Soap or detergent and water	Monitor wash water and plan disposal of it.	The maximum permissible levels for glassware that is handled with the bare hands is the same as for the hands and skin.
	Chromic acid cleaning solution or conc. nitric acid.	" " " "	
	Suggested Agents	Elements Removed	
	Oxalic acid 5%	Zr, Nb, Hf, (Caution Poison)	See Appendix E for filter paper smears.
	Versene (EDTA) 5% conc NH_4OH 3%	Alkaline Earth Metals, Be, Mg, Ca, Sr, Ba, Ra, P as PO_4.	

	HC1 10% by volume	Alkali Metals, Na, K, Rb, Cs, and strongly absorbed metals like Po.	
	To make dissolve in order 1) Versene(EDTA) 5% 2) Conc NH_4OH, 3% by volume 3) Glacial acetic acid 5% by volume	Trivalent metals, Al, Sc, Y, La, Ce, Pr, Nd, Pm, Sa, Eu, Rare Earths, Ac, Ga, In, Ti, B, Transition metals, Cu, Zn, Fe, Co, Ni, Cd, Sn, Hg, Pb, Th, U, Ag. (Always consider the radioactivity of the cleaning solution when disposing of it).	
Laboratory Tools	Detergents & water, steam cleaning	Use mechanical scrubbing action.	The maximum permissible levels for tools that are handled with the bare hands is the same as for the hands and skin.
Metal Tools	Dilute nitric acid, 10% solution of sodium citrate or ammonium biflouride.	As a last resort, use HC1 on stainless steel.	
	Metal polish,	Such as brass polish	

Contaminated Area	Decontaminating Agent	Remarks	Maximum Permissible Levels of Contamination
	sandblasing, other abrasives.	on brass. Use caution as these procedures may spread contamination.	
Plastic Tools	Ammonium citrates, dilute acids, organic solvents.		See Appendix E for Wipe tests.
Glass Tools	The same as above section on glassware.		
Walls Floors Benches	Detergents and water with mechanical action.	This should be the first method of decontamination tried.	
	Vacuum cleaning	The exhaust of the cleaner must be filtered to prevent escape of contamination.	
	Water from high pressure sources Steam cleaning.	This may spread contamination.	

Specific Materials			(Short lived contamination may be covered up to await decay.)
Rubber	Washing or dilute HNO_3.		
Glass Plastic	See the above section.		
Leather	Very difficult to decontaminate.		
Linoleum	$CC1_4$, kerosene, ammonium citrate, dilute mineral acids		
Ceramic Tile	Mineral acids, ammonium citrate, trisodium phosphate	Scrub hot 10% solution into surface & flush thoroughly with hot water.	
Paint	$CC1_4$, 10% HC1 acid	Usually best to remove the paint and repaint.	

Contaminated Area	Decontaminating Agent	Remarks	Maximum Permissible Levels of Contamination
Brick & Concrete	32% HCl acid	If this is not successful, concrete must be removed.	
Wood	Hot citric acid, remove the wood with a plane or floor chippers and grinders.		
Traps & Drains	1) Flush with water 2) Scour with rust remover 3) Soak in a solution of citric acid 4) Flush again.	Follow all 4 steps.	

APPENDIX C

CHARACTERISTICS AND USE OF COMMON SURVEY INSTRUMENTS

A. GEIGER-MUELLER SURVEY INSTRUMENTS

1. Characteristics
   a. Detects gamma rays. Detects betas of 200 kev energy and greater. Thin-mica-window tubes available for low energy beta and alpha detection.
   b. Representative Full Scale Readings:

Beta	Gamma
600 c/m	0.2 or 0.5 mr/hr
6,000 c/m	2.0 or 5.0 mr/hr
60,000 c/m	20.0 or 50.0 mr/hr

   c. Any readings with the G-M meter are very approximate. The instrument should be used only as a qualitative device.
   d. Head phones supplied.
   e. Some instruments read in milliamperes instead of milliroentgens. A calibration curve must be plotted and attached to the instrument.
   f. When placed in a strong field, the G-M instruments will black out and record a zero or low reading. The operator should check for this by moving the G-M tube away from the source of radiation. If the reading increases instead of falling off the meter was blacking out.

2. Application
   a. Should not be used in measuring dosage rates, but rather as a detection instrument.
   b. With shield open indicates beta radiation above approximately 0.2 Mev.
   c. Indicates approximately the magnitude of gamma radiation between intensities of 0.05 mr/hr and 20 mr/hr.

d. Should be used in conjunction with earphones, since earphones respond more quickly to pulses than the count rate meter.
e. Care should be exercised to prevent contamination of probe.
f. Instrument is adjusted to read 10 mr/hr with the shield closed in a gamma radiation field of 10 mr/hr.
g. Due to its extreme sensitivity, the G-M meter is well suited to the detection of low level beta-gamma contamination on clothing, laboratory equipment, personnel, etc.

3. Calibration
a. Source -- Radium-226.
b. The instrument reading vs. actual dose can be plotted for the various scales. See Appendix D on instrument calibration procedure.
c. As an alternative procedure the instrument can be calibrated as follows:

Place probe, with shield closed, in clamp on a calibration stand. Switch to the 20 mr/hr scale, adjust source to give a dose rate of 10 mr/hr. Adjust sensitivity control so that meter reads 10 mr/hr. Check the meter at dose rate positions of 2, 5, and 20 mr/hr and note if the variation of the meter is greater than 10% from these dose rates. If variations do not exceed 10%, instrument may be returned to service.

3a. Pre-calibration check.

1. Check for contamination of instrument (smear).
2. Check general physical condition, i.e., loose knobs, screws, broken wires, etc.
3. Check batteries.
4. Check selector switch and meter functions.
5. Check GM tube for extreme light sensitivity.

B. CUTIE PIE IONIZATION CHAMBER

1. Characteristics
a. Radiation detected: Beta and gamma. Type used at the Center is known as the hard shell or plastic chamber cutie pie.

b. Full scale readings:
   0 - 20 or 50 or 100 mr/hr
   0 - 200 or 500 or 1,000 mr/hr
   0 - 2000 or 5000 or 10,000 mr/hr
   depending on model.
c. Can be zero-set in presence of radiation.
d. Beta radiation is detected through a window in the end of the chamber (0.002" pliofilm). Beta sensitivity depends on geometry, energy of particles, etc.
e. Calibration accuracy ± 10%.

2. Application
   a. The instrument is designed to
      1. Measure, within 10% gamma and x-radiation within the energy range 0.1 to 2 Mev and be- the intensities of 5 and 5,000 mr/hr.
      2. Measure the ion current produced by soft gamma and x-radiation and high energy alpha and beta radiation. The Bakelite wall will stop all betas below 0.7 Mev and the pliofilm window will stop all alphas below approximately 1.0 Mev.
      3. Discriminate, by use of end window, between beta and gamma radiation.
   b. The instrument is not designed to
      1. Measure reps of alpha or beta radiation.
      2. Be used as an alpha survey meter.

3. Factors Affecting Proper Use and Interpretation
   a. Proper warm up time (at least 30 seconds).
   b. Proper zero setting
   c. Proper orientation of instrument.
      1. Maximum beta reading is obtained by pointing the end window toward the source.
      2. Most accurate gamma reading is obtained by holding instrument with chamber at right angles to the beam.
      3. The distance to the point of measurement should be taken to the geometrical center of the chamber.
      4. Indicated dosage rate may vary from true dosage rate when high energy beta radiation is present or if the chamber is too close to a high energy gamma source.

4. Calibration
   a. Pre-calibration check.
      1. Check for contamination of instrument (smear).

2. Check general physical condition, i.e., loose knobs, screws, broken or crushed chamber, etc.
3. Check batteries.
4. Check selector switch and meter functions.
5. Check end window for holes.

b. Source -- 47.8 mg radium (See Instrument Calibration procedure, Appendix D).
c. Allow instrument to warm-up for five minutes. See if the instrument zeros-in on all scales.
d. Orient instrument at right angles to the source.
e. If the instrument has a calibration potentiometer for each scale, adjust each scale at half-deflection. If the instrument has only one calibration potentiometer adjust the middle range to read correctly at half deflection.
f. Plot a true reading vs. the meter reading for each scale and attach to the instrument. If the instrument can be adjusted to read within 5% of the true value for all scales the direct meter reading can be used.

C. PORTABLE SCINTILLATION INSTRUMENTS

1. Characteristics
   a. Detects alpha, beta, and gamma rays. Separate crystals for each type of radiation.
   b. Headphones supplied.
   c. Energy dependent -- more sensitive to low energy radiations.
   d. As an alpha counter.
      1. Uses a thin ZnS screen. This screen is quite insensitive to beta or gamma radiation.
      2. Background approximately 1 c/m.
      3. Efficiency is approximately 20%.
      4. Considered superior to other alpha counters: Not affected by changes in temperature, pressure, humidity, or beta-gamma background. Circuitry is more dependable, less warm up time (1 min.).
   e. As a beta counter.
      Thin organic phosphor (anthracene) used for detector. Covered with a 1 mil. Al light and alpha screen. This system is quite insensitive to alpha or gamma radiation.

f. As a gamma counter.
   1. NaI crystal used for a detector.
   2. Covered with a thick beta shield.
g. These instruments are very sensitive. (Usually to a small fraction of normal background).

2. Application
   a. Care must be taken to prevent damage to the thin light shields covering the beta and alpha crystals.
   b. Light entering the photomultiplier tube while it is turned on, will damage the tube.
   c. Alpha and beta radiations are monitored with the probe in contact with the surface.
   d. Care must be taken to prevent contamination of the probe. For beta and gamma detection, the probe may be covered with a sheet of plastic.
   e. For quantitative measurements reference must be made to the calibration chart.

3. Calibration
   a. Pre-calibration check.
      1. Check for contamination of instrument (smear).
      2. Check general physical condition, i.e., loose knobs, screws, broken wires, etc.
      3. Check batteries.
      4. Check light shield. Hold up to light and observe meter reading.
      5. Check optical contact between photomultiplier and crystal. Add silicone fluid if necessary.
      6. Check selector switch and meter functions.
   b. The beta and alpha crystals are calibrated with extended sources of known activity. The crystal is placed in contact with the source. A calibration chart of activity vs. meter reading is made.
   c. The gamma detector is calibrated the same as the G-M counters. A plot of meter reading vs. actual dose from a radium source is made.

APPENDIX D

INSTRUMENT CALIBRATION PROCEDURE FOR 47.8 mg. RADIUM SOURCE

A. The source is placed on a stand 4 ft. above the ground in a large open area. A calibration area is marked off on the parking lot of the experimental wing.

B. The necessary distances are marked off on a radius from the source (see distance column below).

C. Formula used

$$\text{mr/hr} \quad \frac{K\,M}{d^2}$$

K - 8400 (absorption in 0.5mm Pt)
M - 47.8 mg

$$\text{mr/hr} \quad \frac{445.2}{d^2} \quad \text{(in feet)}$$

d - dist. in cm.
Also 4.6% container correction

D. The mr/hr vs. meter reading is plotted and used as a method of determining actual dose from meter reading.

E. Data Sheet

Distance (feet)	mr/hr	Meter Reading
0.5	1780	_____
1	445	_____
2	111	_____
3	44.5	_____
4	27.8	_____
5	17.8	_____
6	12.4	_____
7	9.1	_____
8	7.0	_____
9	5.5	_____
10	4.4	_____
11	3.7	_____
12	3.1	_____

Distance (feet)	mr/hr	Meter Reading
13	2.6	_____
14	2.3	_____
15	2.0	_____
16	1.7	_____
17	1.5	_____
20	1.1	_____
23	0.84	_____
26	0.66	_____
30	0.44	_____
40	0.28	_____
50	0.18	_____
60	0.12	_____
70	0.09	_____
80	0.07	_____
90	0.06	_____

APPENDIX E

SMEAR SURVEYING TECHNIQUES

It is impossible to detect a small amount of contamination in the presence of a high background of some type of radiation to which the instrument is sensitive. This problem can be avoided by wiping the suspected area with a piece of filter paper and counting the paper in an internal proportional or end window tube counter. This method is more sensitive than most survey instruments. The smear will also give information on the amount of removable contamination. This is an indication of how effective decontamination was or will be. Also the more easily removed activity is much more likely to be inhaled or injected than fixed contamination.

Following is the standard procedure used by the RSO at the Center. The smear is taken over an area the size of one floor tile (9" by 9"). A piece of filter paper 3 to 5 cm in diameter is used. The smear is beta-gamma counted on the first shelf of a shielded end window GM counter. The smear may be counted on an internal proportional counter but care must be taken to avoid charge buildup on the paper. The smear is alpha counted in an internal proportional gas flow counter (charge buildup is usually not a problem in the alpha region).

The accepted permissible levels of contamination currently in use at the Center are:

Type of radiation	Area	Instrument	
		Geiger-Mueller	Internal Proportional
Beta-Gamma	Radioisotope laboratory	50 c/m/smear	100 c/m/smear
	Cold areas	10 c/m/smear	20 c/m/smear
Alpha	Radioisotope laboratory	---	10 c/m/smear
	Cold areas	---	5 c/m/smear

Any area giving smear readings greater than the values in the table will be treated as a contaminated area. These values, although arbitrary, are used because they are believed to give rise to concentrations less than the maximum permissible levels, and are levels which are practical to maintain. Experience shows that it is rarely necessary to draw such fine lines on the permissible c/m. If an area is contaminated some portion of it will usually give a smear count of magnitudes greater than these levels.

APPENDIX F

LEAK TESTING OF SEALED SOURCES

The AEC requires that each licensed source be leak tested at least every six months. The necessity for leak testing sources can be appreciated when the damage that can be caused by one leaking source is considered. Following is a description of tests for leakage suggested by the AEC.

1. Wipe test (for alpha, beta, and/or gamma) - All exposed external surfaces of the object to be tested are wiped thoroughly with a piece of filter paper of high wet strength and absorption capacity, moistened with a solution which will not attack the material of which the container or source holder is made and which, under the conditions of this test, has been demonstrated to be effective in removing the radioisotope involved. The paper is allowed to dry. Then the radioactivity on the paper is measured.

2. Scrub test (beta and/or gamma) - The object to be tested is immersed in a solution which will not attack the material of which the container or source holder is made and which has been demonstrated to be effective in removing the radioisotope involved when the object is scrubbed with a brush under the surface of the liquid. All surfaces of the object are brushed thoroughly under these conditions. The total radioactivity is measured in the residue obtained by evaporation of the solution.

3. Immersion test (beta and/or gamma) - The object to be tested is immersed in a solution which will not attack the material of which the container or source holder is made and which, under the conditions of this test, has been demonstrated to be effective in removing the radioisotope involved.
   The solution is heated to 50 ± 5 degrees Centigrade and held at this temperature for eight hours. The total radioactivity is measured in the residue obtained by evaporation of the solution.

4. Cellulose tape test (beta and/or gamma) - This test is applicable to a device containing a sealed source in a source holder which has an opening through which the radiation emerges. This opening is kept covered for a minimum of seven days with a piece of thin adhesive cellulose tape. The tape is removed carefully and the radioactivity which may have been deposited on its adhesive side is measured.

Also, all major sources at the Center are surrounded with cotton batting and stored in lead pigs. The cotton is frequently removed from the pig and counted with portable beta-gamma and alpha meters. This is considered to be a simple and effective method of leak testing the sources.

APPENDIX G

AIR SAMPLING PROCEDURES

The atmosphere will usually contain large amounts of short-lived natural activity which will mask the longer lived material in which we are interested. The largest component is radon daughters with a half-life of approximately 1/2 hour. If the air sample is allowed to decay 4-5 hours, this activity can be neglected. The remaining natural activity will be due to thoron daughter activity. As the half-life of thoron daughters is 10.6 hours, 3-4 days will be required to allow for decay. Frequently, information will be desired as soon as possible. To do this, a first count can be made after the radon daughter activity decays (4-5 hours) and a second count some time later (10 hours). The long-lived activity is given as:

$$C_{LL} = \frac{C_2 - C_1 e^{-\lambda \Delta t}}{1 - e^{-\lambda \Delta t}}$$

Where

C_{LL} - counts/min of long-lived activity

C_1 - first count

C_2 - second count

λ - decay constant for thoron - 0.0655 hr^{-1}

Δt - time between counts in hours

The activity concentration in air is:

$$\mu c/ml = \frac{(C/M)\ (1.6 \times 10^{-9})}{(Eff.)\ (Ft^3)}$$

Where

C/M - counts/min above background

Ft^3 - cubic feet of air sampled

Eff. - counting efficiency in per cent

The sample can be put in a vial and inserted in a well type crystal to be scanned by a gamma spectrometer. This will allow for the identification of any gamma emitters in the air.

Allowable concentrations of radionuclides are:

(1) without mask*
Alpha 5×10^{-12} μc/ml or 0.32 d/m/ft^3

Beta-Gamma 10^{-9} μc/ml or 63. d/m/ft^3

(2) With filter type mask**
Alpha 5×10^{-9} μc/ml or 320 d/m/ft^3

Beta-Gamma 10^{-6} μc/ml or 6.3×10^4 d/m/ft^3

A filter type mask is mounted in a red box in the hallway of each wing of the building.

(3) With positive air supply
Control by external hazard.

A self contained mask is located in the first aid room on the first floor.

* Handbook 52 values for non-control areas used.

** Assumes 99% effectiveness for mask. This is generally true for normal particulate dispersions.

APPENDIX H

PROCEDURE FOR DISPOSING OF WASTES BY SEWER

Wastes may be disposed of by the drains in the individual laboratories if the levels are below the values cited in the Federal Register, Chapter 1, Part 20, Appendix B, Table 1, Column 2. A copy of this Federal Register is included as Appendix J of this manual. The only dilution that can be computed is that which is immediately available. Approval of this disposal must be obtained from the RSO and record of the disposal must be made on waste disposal forms supplied by the RSO.

An assay must be made to determine the exact amounts of activity present and the dilution necessary. The assay procedure for non-volatile substances is to evaporate a known amount on a planchet and count in an internal proportional counter. The activity can be found by the formula

$$\mu c/ml = \frac{4.5 \times 10^3}{\text{(counting efficiency in per cent)} \quad \text{(per cent counted of total emissions)} \quad \text{(ml of sample)}}$$

$$\text{and dilution factor} \quad \frac{\mu c/ml \text{ of the waste}}{\mu c/ml \text{ permissible in water}}$$

For wastes requiring larger dilution factors than available in the laboratory, disposal may be made in the sewer leaving the building. The RSO has information on the sewer location, flow rates, and the procedure to be used.

APPENDIX I

CONDITIONS OF LICENSE

Licenses issued by the Atomic Energy Commission stipulate certain additional conditions which must be adhered to by the licensee. The conditions required of the Center are outlined below.

U. S. ATOMIC ENERGY COMMISSION BY-PRODUCT MATERIAL LICENSE

Pursuant to the Atomic Energy Act of 1954 and Title 10, Code of Federal Regulations, Chapter 1, Part 30, Licensing of By-product Material, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, own, possess, transfer, and import by-product material listed below; and to use such by-product material for the purpose(s) and at the place(s) designated below. This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, and is subject to all applicable rules, regulations, and orders of the Atomic Energy Commission now or hereafter in effect and to any conditions specified below.

---

1. Name of Licensee
2. Address of Licensee
3. License Number
4. Expiration Date
5. Reference Number
6. By-product Material (element and mass number)
   Any by-product material between Atomic Nos. 3 and 83, incl.
7. Chemical and/or Physical Form
   Any
8. Maximum Amount of Radioactivity Which Licensee May Possess at Any One Time
   Total possession limit not to exceed 15 curies
9. Authorized Use
   RESEARCH AND DEVELOPMENT as defined in Section 11 (q) of the Atomic Energy Act of 1954.

CONDITIONS

10. Unless otherwise specified, the authorized place of use is the licensee's address stated in item 2 above.
11. By-product materials are to be used by, or under the supervision of, individuals designated by the Local Isotope Committee.
12. The licensee shall comply with the provisions of Title 10, Part 20, Code of Federal Regulations, Chapter I, "Standards for Protection Against Radiation".

Exception:

Notwithstanding section 20.24 (f) of said standards, labeling shall not be required for laboratory containers such as beakers, flasks and test tubes, used transiently in laboratory procedures during presence of the user.

13. By-product material procured as sealed sources shall not be opened.
14. Leak testing of sealed sources containing beta and/or gamma emitting by-product material except those containing iridium-192, tantalum-182, gold-198, and plated cobalt-60 in discrete metallic form, shall be carried out at intervals of six months and records of the leak test results shall be furnished the Atomic Energy Commission upon request.
15. Written administrative instructions covering appropriate radiological protection phases of operational procedures and establishing responsibility for radiological protection, control, and security of the by-product material shall be supplied individuals using or having responsibility for use of such material.
16. Licensee shall report to the Commission immediately upon discovery thereof any incident which has resulted or have resulted in an exposure to any individual in excess of a dose of 3 rem within a 24-hour period or any incident involving loss of the licensed material.
17. By-product material shall not be used in:
    A. or on human beings.
    B. products distributed to the public.
    C. field applications except by special authorization.
18. As requested in letter from Chairman, Radiation Safety and Isotope Committee, Broad License No. 0000 is hereby amended to add the following condition:
    A. Not withstanding Condition 17.C, approval is given

for the field use of phosphorus-32 to be used in training demonstrations and student exercises involving simulated radioactive fallout contamination and related problems of hazard evaluation and decontamination procedures for food, water, and various surface materials.

B. All field uses of radioactive materials shall be performed by or under the direct supervision of radiological health training specialists designated by the Radioisctope Committee.

C. All radioactive materials, including wastes, used in field demonstrations and training exercises shall be returned to the Address of the Licensee pending final disposal.

19. Notwithstanding Condition 17.C., approval is given for the field use of cobalt-60 sealed sources, not to exceed a total of 50 millicuries, for calibration of survey monitoring instruments and training purposes.
20. Approval is given to procure hydrogen 3 (tritium) in any chemical or physical form. The total amount of hydrogen 3 (tritium) procured under this license shall not exceed 1.5 curies.
21. Written administrative instructions entitled "Radiation Safety Manual" and dated April 13, 1959, covering radiological protection, control, and security of by-product material shall be followed and a copy of this manual shall be supplied to each individual using or having responsibility for use of such material. Any changes in the administrative instructions shall have the prior approval of the Isotopes Branch, Division of Licensing and Regulation.

APPENDIX J

FEDERAL REGISTER

VOLUME 22 NUMBER 19

Washington, Tuesday, January 29, 1957

STANDARDS

FOR

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PROTECTION

TITLE 10—ATOMIC ENERGY

Chapter I—Atomic Energy Commission

PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

In July 1955 the Commission issued for public comment a proposed regulation to establish general standards for protection of licensees, their employees, and the public against radiation hazards arising out of the possession or use of special nuclear, source, or byproduct material under license issued by AEC. In preparing the effective regulation published below, the Commission has had the benefit of numerous comments and suggestions received since publication of the proposed rules. A number of changes suggested by those comments have been incorporated in the following regulation.

The regulation establishes standards which must be followed in handling radioactive materials which are subject to the licensing authority of the Commission and provides procedures whereby deviations from such standards may be authorized on a case-to-case basis. The regulation prescribes limits which govern exposure of personnel to radiation and concentrations of radioactive material, concentrations of radioactive material which may be discharged into air and water, and disposal of radioactive wastes. It also establishes certain precautionary procedures and administrative controls.

The standards established by this regulation will be found to agree substantially with those published by the National Committee on Radiation Protection in N. B. S. Handbook 52 "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water," and N. B. S. Handbook 59 "Permissible Dose from External Sources of Ionizing Radiation." The National Committee on Radiation Protection has under review recommendations to limit cumulative exposures over periods of years. The Commission is giving consideration to appropriate amendments to its regulations to deal with this cumulative exposure problem.

Limitations upon levels of radiation and concentrations of radioactive material in areas affected by but not controlled by the licensee are contained principally in § 20.102 ("Permissible Levels of Radiation in Unrestricted Areas"), § 20.103 ("Concentrations in Effluents to Unrestricted Areas"), and the sections on waste disposal. The sections are designed to assure that individuals in "unrestricted areas" do not receive exposure in excess of 10 percent of the limits established for persons exposed in restricted areas. For this purpose, the sections limit levels of radiation and concentrations of radioactive material which may be created in unrestricted areas by licensees, without special authorization from the AEC, to extremely low levels. These levels are believed to be sufficiently low to assure that there is no reasonable probability of individuals in unrestricted areas receiving exposures in excess of 10 percent of the permissible levels for restricted areas. Procedures are incorporated in those sections, however, under which the Commission may authorize licensees in specific cases to create higher levels in unrestricted areas where the circumstances of the particular case are such as to provide reasonable assurance that individuals in the unrestricted areas will not receive exposures in excess of 10 percent of the limitation established for restricted areas.

It is believed that the standards incorporated in these regulations provide, in accordance with present knowledge, a very substantial margin of safety for exposed individuals. It is believed also that the standards are practical from the standpoint of licensees. It should be emphasized that the standards are subject to change with the development of new knowledge, with significant increase in the average exposure of the whole population to radiation, and with further experience in the administration of the Commission's regulatory program.

Pursuant to the Administrative Procedures Act, Public Law 404, 79th Congress, 2d Session, the following rules are published as a document subject to codification to be effective 30 days after publication in the FEDERAL REGISTER.

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AUTHORITY: §§ 20.1 to 20.601 issued under sec. 161 (b), 68 Stat 948, 42 U. S. C. 2201.

GENERAL PROVISIONS

§ 20.1 *Purpose.* (a) The regulations in this part establish standards for protection against radiation hazards arising out of activities under licenses issued by the Atomic Energy Commission and are issued pursuant to the Atomic Energy Act of 1954 (68 Stat. 919).

(b) The use of radioactive material or other sources of radiation not licensed by the Commission is not subject to the regulations in this part. However, it is the purpose of the regulations in this part to control the possession, use, and transfer of licensed material by any licensee in such a manner that exposure to such material and to radiation from such material, when added to exposures to unlicensed radioactive material and to other unlicensed sources of radiation in the possession of the licensee, and to radiation therefrom, does not exceed the standards of radiation protection prescribed in the regulations in this part.

§ 20.2 *Scope.* The regulations in this part apply to all persons who receive, possess, use or transfer byproduct material, source material, or special nuclear material under a general or specific license issued by the Commission pursuant to the regulations in Part 30, 40, or 70 of this chapter.

§ 20.3 *Definitions.* (a) As used in this part:

(1) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

(2) "Airborne radioactive material" means any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases;

(3) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

(4) "Commission" means the Atomic Energy Commission or its duly authorized representatives;

(5) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

(6) "Individual" means any human being;

(7) "Licensed material" means source material, special nuclear material, or byproduct material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter;

(8) "License" means a license issued under the regulations in Part 30, 40, or 70 of this chapter. "Licensee" means the holder of such license;

(9) "Person" means (i) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission, any State, any foreign government or nation or any political subdivision of any such government or nations, or other entity; and

(ii) any legal successor, representative, agent, or agency of the foregoing;

(10) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light;

(11) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission;

(12) "Restricted area" means any area access to which is controlled by the licensee. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area;

(13) "Source material" means any material except special nuclear material, which contains by weight one-twentieth of one percent (0.05 percent or more of (i) uranium, (ii) thorium, or (iii) any combination thereof;

(14) "Special nuclear material" means (i) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (ii) any material artificially enriched by any of the foregoing but does not include source material;

(15) "Unrestricted area" means any area entry into which is not controlled by the licensee, and any area used for residential quarters.

(b) Definitions of certain other words and phrases as used in this part are set forth in other sections, including:

(1) "Airborne radioactivity area" defined in § 20.203;

(2) "Radiation area" and "high radiation area" defined in § 20.202;

(3) "Personnel monitoring equipment" defined in § 20.202;

(4) "Survey" defined in § 20.201;

(5) Units of measurement of dose (rad, rem) defined in § 20.4;

(6) Units of measurement of radioactivity defined in § 20.5.

§ 20.4 *Units of radiation dose.* (a) "Dose," as used in this part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section.

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad) = 0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem) = 0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

(1) A dose of 1 r due to X— or gamma radiation;

(2) A dose of 1 rad due to X—, gamma, or beta radiation;

(3) A dose of 0.1 rad due to neutrons or high energy protons;

(4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye;

If it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in subparagraph (3) of this paragraph, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

Neutron energy	Number of neutrons per square centimeter equivalent to a dose of 1 rem
Thermal	980 × 10^6
0.0001 mev	480 × 10^6
0.01 mev	480 × 10^6
0.1 mev	95 × 10^6

Neutron energy	Number of neutrons per square centimeter equivalent to a dose of 1 rem
0.5 mev	38×10^6
1 mev	29×10^6
2 mev	19×10^6
3 mev. and higher	14×10^6

§ 20.5 *Units of radioactivity.* (a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies. One curie (c) $=3.7\times10^{10}$ disintegrations per second (dps) $=2.2\times10^{12}$ disintegrations per minute (dpm). A commonly used submultiple of the curie is the microcurie (μc). One μc$=0.000001$ c$=3.7\times10^4$ dps$=2.2\times10^6$ dpm.

NOTE: Many radioisotopes disintegrate into isotopes which are also radioactive. In expressing maximum permissible concentrations in air and water of these materials, as in Appendix B of this part, the activity stated is that of the parent isotope. In some cases, the fact that daughter products may contribute to the total dose has been taken into account in the determination of the maximum permissible concentration of the parent isotopes. In the tables of Appendix B of this part this is indicated by writing $Ba^{140}+La^{140}$, $Sr^{90}+Y^{90}$, $Rn^{222}+dr$, $Ra^{228}+\frac{1}{2}$ dr, etc.

EXAMPLE. In Column 1, Table I, Appendix B the maximum permissible concentration of Ba^{140} in air for occupational use is $2+10^{-7}$ μc/ml. This is the maximum permissible concentration regardless of whether or not any of the La^{140} which may have resulted from the decay of the Ba^{140} is present or not. However, the value given for BA^{140} is less than it would be if La^{140} were a stable isotope, not only because of the possibility of La^{140} in the air but principally because, if the Ba^{140} is inhaled, its radioactive decay in the body will result in the production of La^{140} in the body.

(b) *Radon.* Airborne radioactivity of radon and its decay products may be determined by measurement of the activity of one or more decay products on dust filtered from the air. For purposes of the regulations in this part, the limit prescribed here will be considered to be met if the measured radioactivity of one or more decay products (for example, RaC') does not exceed that which would result from the occurrence, at the time of sampling, of 1×10^{-7} microcuries, per milliliter of air, of Rn^{222} and each of its short-lived decay products, RaA, RaB, RaC, and RaC'. For this purpose, due allowance shall be made for changes in the radioactivity of the measured decay products from time of sampling through the period of measurement.

(c) *Natural uranium and natural thorium.* Natural uranium and natural thorium occur as mixtures of isotopes of the respective elements. In the case of uranium or of thorium, the number of microcuries shall be determined by dividing the total rate, in dpm, of alpha emissions from the mixture by 2.2×10^6 dpm per μ c.

§ 20.6 *Interpretations.* Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.7 *Communications.* All communications and reports concerning the regulations in this part, and applications filed under them, should be addressed to the Atomic Energy Commission, 1901 Constitution Avenue NW., Washington 25, D. C., Attention: Division of Civilian Application.

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

§ 20.101 *Exposure of individuals in restricted areas*—(a) *Exposure to radiation.* (1) Except as provided in subparagraph (2) of this paragraph, no licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual in a restricted area to receive in any period of seven consecutive days from radioactive material and other sources of radiation in the licensee's possession a dose in excess of the limits specified in Appendix A of this part.

(2) A licensee may permit an individual in a restricted area to receive a dose in excess of the limits established in subparagraph (1) of this paragraph: *Provided,* (i) That the dose during any period of 7 consecutive days does not exceed three times the limits specified in Appendix A of this part, and (ii) that the dose during any period of 13 consecutive weeks does not exceed 10 times the limits specified in Appendix A of this part.

(b) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual in a restricted area to be exposed to airborne radioactive material possessed by the li-

censee in an average concentration in excess of the limits specified in Appendix B, Table I, of this part.

The limits given in Appendix B, Table I of this part, are based upon exposure to the concentrations specified for forty hours in any period of seven consecutive days. In any such period where the number of hours of exposure is less than forty, the limits specified in the table may be increased proportionately. In any such period, where the number of hours of exposure is greater than forty, the limits specified in the table shall be decreased proportionately.

(c) *Exposure of minors.* No licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual under 18 years of age within a restricted area to receive in any period of seven consecutive days from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in Appendix A of this part, or to be exposed to airborne radioactive material possessed by the licensee in a concentration in excess of the limits specified in Appendix B, Table II, of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than a week.

§ 20.102 *Permissible levels of radiation in unrestricted areas.* (a) There may be included in any application for a license or for amendment of a license proposed limits upon levels of radiation in unrestricted areas resulting from the applicant's possession or use of radioactive material and other sources of radiation. Such applications should include information as to anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that the proposed limits are not likely to cause any individual to receive a dose in any period of seven consecutive days in excess of 10 percent of the limits specified in Appendix A of this part.

(b) Except as authorized by the Commission pursuant to paragraph (a) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

§ 20.103 *Concentrations in effluents to unrestricted areas.* (a) There may be included in any application for a license or for amendment of a license proposed limits upon concentrations of licensed and other radioactive material released into air or water in unrestricted areas as a result of the applicant's proposed activities. Such applications should include information as to anticipated average concentrations and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that it is not likely that any individual will be exposed to concentrations in excess of the limits specified in Appendix B, Table II, of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than one year.

(b) Except as authorized by the Commission pursuant to § 20.302 or paragraph (a) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to release into air or water in any unrestricted area any concentration of radioactive material in excess of the limits specified in Appendix B, Table II of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than one year.

(c) For purposes of this section, determinations as to the concentration of radioactive material shall be made with respect to the point where such material leaves the restricted area. Where the radioactive material leaves the restricted area in a stack, tube, pipe, or similar conduit, the determination may be made with respect to the point where the material leaves such conduit.

(d) The provisions of this section do not apply to disposal of radioactive material into sanitary sewerage systems (see § 20.303).

§ 20.104 *Medical diagnosis, therapy, and research.* Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

§ 20.105 *Measures to be taken after excessive exposures.* In the event that any individual in a restricted area receives a dose or is exposed to concentrations of radioactive material in excess of the permissible limits established in § 20.101, the licensee shall limit the weekly dose or exposure of the individual to 10 percent of such permissible limit until such time as the average weekly dose or exposure to the individual for the period beginning with the week in which the excessive dose or exposure occurred is less than the permissible limit established in § 20.101.

PRECAUTIONARY PROCEDURES

§ 20.201 *Surveys.* (a) As used in the regulations in this part, "survey" means an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive material present.

(b) Each licensee shall make or cause to be made such surveys as may be necessary for him to comply with the regulations in this part.

§ 20.202 *Personnel monitoring.* (a) Each licensee shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by:

(1) Each individual who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in excess of 25 percent of the limits specified in Appendix A of this part;

(2) Each individual who enters a high radiation area.

(b) As used in this part,

(1) "Personnel monitoring equipment" means devices designed to be worn or carried by an individual for the purpose of measuring the dose received (e. g., film badges, pocket chambers, pocket dosimeters, film rings, etc.);

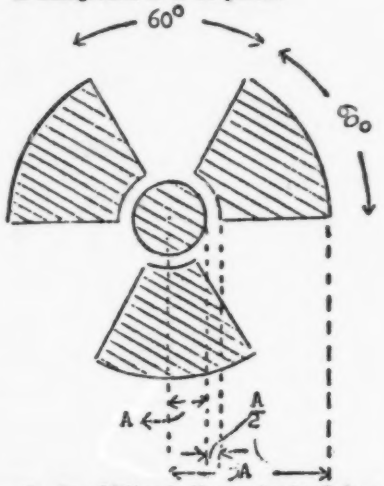
(2) "Radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 150 millirem;

(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

§ 20.203 *Caution signs, labels, and signals.* (a) (1) Except as otherwise authorized by the Commission, symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this section is the conventional three-bladed design:

RADIATION SYMBOL

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.



(2) In addition to the contents of signs and labels prescribed in this section, licensees may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation or to radioactive material.

(b) *Radiation areas.* Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]
RADIATION AREA

(c) *High radiation areas.* (1) Each high radiation area shall be conspicuously posted with a sign or signs bearing

[1] Or "Danger".

the radiation caution symbol and the words:

CAUTION [1]
HIGH RADIATION AREA

(2) Each high radiation area shall be equipped with a control device which shall either cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirem in one hour upon entry into the area or shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering and the licensee or a supervisor of the activity are made aware of the entry. In the case of a high radiation area established for a period of 30 days or less, such control device is not required.

(d) *Airborne radioactivity areas.* (1) As used in the regulations in this part, "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix B, Table I, Column 1 of this part; or (ii) any room, enclosure, or operating area in which airborne radioactive material composed wholly or partly of licensed material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in Appendix B, Table I, Column 1 of this part.

(2) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]
AIRBORNE RADIOACTIVITY AREA

(e) *Additional requirements.* (1) Each area or room in which licensed material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in an amount exceeding 10 times the quantity of such material specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]
RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in an amount exceeding one-hundred times the quantity specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]
RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Each container in which is transported, stored, or used a quantity of any licensed material (other than natural uranium or thorium) greater than the quantity of such material specified in Appendix C of this part shall bear a durable, clearly visible label bearing the radiation caution symbol and the words:

[1] Or "Danger."

CAUTION [1]
RADIOACTIVE MATERIAL

(2) Each container in which natural uranium or thorium is transported, stored, or used in a quantity greater than ten times the quantity specified in Appendix C of this part shall bear a durable, clearly visible label bearing the radiation caution symbol and the words:

CAUTION [1]
RADIOACTIVE MATERIAL

(3) Notwithstanding the provisions of subparagraphs (1) and (2) a label shall not be required:

(i) If the concentration of the material in the container does not exceed that specified in Appendix B, Table I, Column 2 of this part, or

(ii) For laboratory containers, such as beakers, flasks, and test tubes, used transiently in laboratory procedures, when the user is present.

(4) Where containers are used for storage, the labels required in this paragraph shall state also the quantities and kinds of radioactive materials in the containers and the date of measurement of the quantities.

§ 20.204 *Exceptions from posting requirements.* Notwithstanding the provisions of § 20.203,

(a) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level twelve inches from the surface of the source container or housing does not exceed five millirem per hour.

(b) Rooms or other areas in hospitals are not required to be posted with caution signs because of the presence of patients containing byproduct material provided that there are personnel in attendance who shall take the precautions necessary

to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the regulations in this part.

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours provided that (1) the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations in this part and; (2) such area or room is subject to the licensee's control.

§ 20.205 *Exemptions for radioactive materials packaged for shipment.* Radioactive materials packaged and labeled in accordance with regulations of the Interstate Commerce Commission shall be exempt from the labeling and posting requirements of § 20.203 during shipment, provided that the inside containers are labeled in accordance with the provisions of § 20.203 (f).

§ 20.206 *Instruction of personnel.* All individuals working in or frequenting any portion of a restricted area shall be informed of the occurrence of radioactive materials or of radiation in such portion, and shall be instructed in the hazards of excessive exposure to such materials or radiation and in precautions or procedures to minimize exposure.

§ 20.207 *Storage of licensed material.* Licensed materials stored in an unrestricted area shall be secured against unauthorized removal from the place of storage.

WASTE DISPOSAL

§ 20.301 *General requirement.* No licensee shall dispose of licensed material except:

(1) By transfer to an authorized recipient as provided in the regulations in Part 30, 40, or 70 of this chapter, whichever may be applicable; or

(2) As authorized pursuant to § 20.302; or

(3) As provided in § 20.303 or § 20.304, applicable respectively to the disposal of licensed material by release into sanitary sewerage systems or burial in soil, or in § 20.103 (Concentrations in Effluents to Unrestricted Areas).

§ 20.302 *Method for obtaining approval of proposed disposal procedures.* Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

§ 20.303 *Disposal by release into sanitary sewerage systems.* No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of subparagraphs (1) or (2) of this paragraph:

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix B, Table I, Column 2 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix B, Table I, Column 2 of this part; and

(d) The gross quantity of licensed and other radioactive material released into the sewerage system by the licensee does not exceed one curie per year.

Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

§ 20.304 *Disposal by burial in soil.* No

licensee shall dispose of licensed material by burial in soil unless:

(a) The total quantity of licensed and other radioactive materials buried at any one location and time does not exceed, at the time of burial, 1,000 times the amount specified in Appendix C of this part; and

(b) Burial is at a minimum depth of four feet; and

(c) Successive burials are separated by distances of at least six feet and not more than 12 burials are made in any year.

RECORDS, REPORTS, AND NOTIFICATION

§ 20.401 *Records of surveys, radiation monitoring, and disposal.* (a) Each licensee shall maintain records showing the radiation exposures of all individuals subject to personnel monitoring control under § 20.202 of the regulations in this part.

(b) Each licensee shall maintain records showing the name of each individual exposed to radiation pursuant to § 20.101 (a) (2) and the weekly dose of each such individual for the 13 consecutive weeks of highest cumulative weekly dose.

(c) Each licensee shall maintain records in the same units used in the appendices to this part, showing the results of surveys required by § 20.201 (b), and disposals made under §§ 20.302, 20.303, and 20.304.

§ 20.402 *Reports of theft or loss of licensed material.* Each licensee shall report promptly to the Commission, after its occurrence becomes known to the licensee, any loss or theft of licensed material in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

§ 20.501 *Applications for exemptions.* The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 20.502 *Additional requirements.* The Commission may, by rule, regulation, or order, impose upon any licensee such requirements, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

ENFORCEMENT

§ 20.601 *Violations.* An injunction or other court order may be obtained prohibiting any violation of any provision of the act or any regulation or order issued thereunder. Any person who willfully violates any provision of the act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

APPENDIX A

PERMISSIBLE WEEKLY DOSE

Conditions of exposure		Dose in critical organs (mrem)			
Parts of body	Radiation	Skin, at basal layer of epidermis	Blood forming organs	Gonads	Lens of eye
Whole body	Any radiation with half-value-layer greater than 1 mm of soft tissue.	[1] 600	[1] 300	[1] 300	[1] 300
Whole body	Any radiation with half-value-layer less than 1 mm of soft tissue.	1,500	300	300	300
Hands and forearms or feet and ankles or head and neck.	Any radiation	[2] 1,500			

[1] For exposures of the whole body to X or gamma rays up to 3 mev, this condition may be assumed to be met if the "air dose" does not exceed 300 mr, provided the dose to the gonads does not exceed 300 mrem. "Air dose" means that the dose is measured by an appropriate instrument in air in the region of highest dosage rate to be occupied by an individual, without the presence of the human body or other absorbing and scattering material.

[2] Exposure of these limited portions of the body under these conditions does not alter the total weekly dose of 300 mrem permitted to the bloodforming organs in the main portion of the body, to the gonads, or to the lens of the eye.

RULES AND REGULATIONS

APPENDIX B

PERMISSIBLE CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

Material	Table I		Table II	
	Column 1 [1] Air (2)	Column 2 [2] Water (3)	Column 1 [1] Air (2)	Column 2 [2] Water (3)
A^{41}	1.6×10^{-6}	1.4×10^{-6}	5×10^{-6}	5×10^{-6}
Ag^{105}	3.6×10^{-6}	5	1.2×10^{-6}	1.6×10^{-6}
Ag^{111}	1×10^{-6}	13	5×10^{-6}	4×10^{-6}
Am^{241}	8×10^{-11}	4×10^{-6}	3×10^{-10}	1.3×10^{-6}
As^{76}	7×10^{-6}	6×10^{-5}	2×10^{-7}	2×10^{-6}
At^{211}	9×10^{-10}	6×10^{-6}	3×10^{-11}	2×10^{-7}
Au^{198}	3.4×10^{-7}	9×10^{-6}	1.1×10^{-6}	3×10^{-6}
Au^{199}	8×10^{-7}	2×10^{-5}	2.5×10^{-6}	7×10^{-6}
$Ba^{140}+La^{140}$	2×10^{-7}	6×10^{-6}	8×10^{-6}	2×10^{-5}
Be^{7}	1.3×10^{-6}	3	4×10^{-7}	1×10^{-5}
C^{14}	1.4×10^{-6}	1×10^{-6}	5×10^{-6}	3.6×10^{-6}
Ca^{45}	9×10^{-6}	1.5×10^{-6}	3×10^{-6}	5×10^{-6}
$Cd^{109}+Ag^{109}$	2×10^{-7}	2×10^{-5}	7×10^{-6}	7×10^{-6}
$Ce^{141}+Pr^{144}$	2×10^{-6}	1×10^{-5}	7×10^{-10}	3.6×10^{-6}
Cl^{36}	1×10^{-6}	7×10^{-6}	4×10^{-6}	2.4×10^{-6}
Cm^{242}	8×10^{-10}	2.7×10^{-5}	1.8×10^{-11}	1×10^{-6}
Co^{60}	3.4×10^{-6}	5×10^{-6}	1.2×10^{-7}	1.8×10^{-6}
Cr^{51}	2.4×10^{-6}	1.4	8×10^{-7}	5×10^{-6}
$Cs^{137}+Ba^{137}$	6×10^{-7}	4.5×10^{-6}	2×10^{-6}	1.5×10^{-6}
Cu^{64}	2×10^{-5}	3.5×10^{-5}	6×10^{-7}	8×10^{-6}
Eu^{155}	2×10^{-6}	1×10^{-5}	6×10^{-10}	3×10^{-6}
F^{18}	2.5×10^{-5}	2.6	1.2×10^{-6}	9×10^{-6}
Fe^{55}	1.8×10^{-6}	1.3×10^{-6}	6×10^{-6}	4×10^{-5}
Fe^{59}	8×10^{-6}	2.3×10^{-6}	1.5×10^{-6}	1.1×10^{-6}
Ga^{72}	1×10^{-6}	28	3.4×10^{-7}	9×10^{-5}
Ge^{71}	1×10^{-5}	27	3.6×10^{-6}	9×10^{-5}
H^{3} (HTO or T_2O)	7×10^{-5}	5×10^{-5}	2.5×10^{-6}	1.6×10^{-6}
Ho^{166}	1×10^{-5}	70	3×10^{-7}	2.3
I^{131}	9×10^{-6}	9×10^{-6}	3×10^{-10}	3×10^{-6}
Ir^{192}	2.2×10^{-6}	4×10^{-6}	7×10^{-6}	1.3×10^{-6}
Ir^{194}	1.5×10^{-7}	2.7×10^{-5}	5×10^{-6}	9×10^{-7}
K^{42}	6×10^{-6}	4×10^{-5}	2×10^{-7}	1.4×10^{-5}
La^{140}	4×10^{-6}	3.4	1.4×10^{-7}	1.1×10^{-4}
Lu^{177}	1.5×10^{-5}	70	5×10^{-7}	2.4
Mn^{56}	8×10^{-6}	5×10^{-4}	3×10^{-7}	1.5×10^{-6}
Mo^{99}	5×10^{-6}	40	1.8×10^{-6}	1.4
Na^{24}	5×10^{-6}	2.4×10^{-5}	1.6×10^{-7}	8×10^{-6}
Nb^{95}	1.3×10^{-6}	1.2×10^{-5}	4×10^{-6}	4×10^{-6}
Ni^{65}	5×10^{-6}	7×10^{-4}	1.6×10^{-6}	2.5×10^{-6}
P^{32}	4×10^{-7}	6×10^{-6}	1.4×10^{-6}	2×10^{-6}
Pb^{203}	2×10^{-6}	4×10^{-4}	6×10^{-7}	1.4×10^{-6}
$Pb^{210}+Rb^{210}$	2×10^{-6}	3×10^{-3}	7×10^{-6}	1×10^{-6}
Pm^{147}	6×10^{-7}	3	2×10^{-6}	1×10^{-5}
Po^{210} (soluble)	6×10^{-10}	9×10^{-3}	2×10^{-11}	3×10^{-6}
Po^{210} (insoluble)	2×10^{-10}		7×10^{-13}	
Pr^{142}	2.3×10^{-6}	1	7×10^{-6}	3.6×10^{-6}
Pu^{239} (soluble)	6×10^{-13}	4.5×10^{-6}	2×10^{-13}	1.5×10^{-7}
Pu [239] (Insoluble)	6×10^{-13}		2×10^{-13}	
Ra [226]+1/2 dr	2.4×10^{-11}	1.2×10^{-7}	8×10^{-13}	4×10^{-6}
Rb [86]	1.1×10^{-6}	9×10^{-7}	4×10^{-6}	3×10^{-6}
Re [186]	2.4×10^{-5}	2.4×10^{-7}	8×10^{-7}	8×10^{-6}
Rh [105]	3×10^{-6}	5×10^{-6}	1×10^{-7}	1.6×10^{-6}
Rh [106]+dr	1×10^{-7}	6×10^{-6}	3.3×10^{-6}	2×10^{-7}
$Ru^{106}+Rh^{106}$	8×10^{-6}	4×10^{-7}	2.6×10^{-6}	1.3×10^{-5}
S[35]	3×10^{-6}	1.5×10^{-6}	1×10^{-7}	5×10^{-7}
Sb^{124}	2×10^{-7}	1	7×10^{-6}	3.6×10^{-6}
Se^{75}	4×10^{-6}	6×10^{-7}	1.3×10^{-6}	2×10^{-6}
Sm^{153}	1.7×10^{-6}	5×10^{-7}	6×10^{-6}	1.6×10^{-6}
Sn [113]	6×10^{-6}	2×10^{-6}	2×10^{-6}	7×10^{-6}
Sr^{89}	6×10^{-10}	2.4×10^{-6}	2×10^{-11}	8×10^{-6}
$Sr^{90}+Y^{90}$	8×10^{-6}	5×10^{-6}	3×10^{-7}	3×10^{-6}
Te^{89}	3×10^{-6}	5×10^{-5}	1×10^{-6}	3×10^{-6}
Te^{127}	1.2×10^{-7}	3.3×10^{-5}	4×10^{-5}	1.1×10^{-6}
Te^{132}	2×10^{-6}	10	6×10^{-6}	3×10^{-7}
Th^{234}	6×10^{-11}	1.5×10^{-6}	1.7×10^{-13}	5×10^{-6}
Th-natural (soluble)	6×10^{-11}		1.7×10^{-13}	
Th-natural (insoluble)	1.5×10^{-7}	8×10^{-7}	5×10^{-9}	2.5×10^{-6}
Tm^{170}	6×10^{-11}	2×10^{-6}	1.7×10^{-13}	7×10^{-6}
U-natural (soluble) [3]	5×10^{-11}		1.7×10^{-13}	
U-natural (insoluble) [3]	4×10^{-10}	4.5×10^{-6}	1×10^{-11}	1.5×10^{-6}
U^{235} (soluble)	5×10^{-11}		1.6×10^{-13}	
U^{235} (insoluble)	3×10^{-4}	1.5	1×10^{-7}	5×10^{-6}
V^{48}	1.3×10^{-6}	1.3×10^{-6}	4×10^{-7}	4×10^{-6}
Xe^{135}	5×10^{-6}	4×10^{-6}	1.7×10^{-7}	1.4×10^{-6}
Xe^{133}	1.2×10^{-7}	6×10^{-5}	4×10^{-6}	2×10^{-6}
Y^{91}	6×10^{-6}	2×10^{-5}	2×10^{-7}	6×10^{-6}
Zn^{65}				

APPENDIX B—Continued

PERMISSIBLE CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

Material	Table I		Table II	
	Column 1 [1] Air [2]	Column 2 [3] Water (3)	Column 1 [1] Air (2)	Column 2 [3] Water (3)
Unidentified beta or gamma emitters or any undetermined mixtures of beta or gamma emitters			1×10^{-9}	1×10^{-7}
Unidentified alpha emitters or any undetermined mixtures of alpha emitters			5×10^{-13}	1×10^{-7}

[1] Air concentrations are given in microcuries per milliliter of air.
[2] Water concentrations are given in microcuries per milliliter of water. These figures also apply to foodstuffs in microcuries per gram (wet-weight).
[3] For enriched uranium the same radioactivities per unit volume as those for natural uranium are applicable. It should be noted that the contribution of U-234 to the gross activity of enriched uranium is 20–40 times that of the U-238.

APPENDIX C

Material	Microcuries
Ag^{105}	1
Ag^{111}	10
As^{73}, As^{77}	10
Au^{196}	10
Au^{199}	10
$Ba^{140}+La^{140}$	1
Be^{7}	50
C^{14}	50
Ca^{45}	10
$Cd^{109}+Ag^{109}$	10
$Ce^{144}+Pr^{144}$	1
Cl^{36}	1
Co^{60}	1
Cr^{51}	50
$Cs^{137}+Ba^{137}$	1
Cu^{64}	50
Eu^{152}	1
F^{18}	50
Fe^{59}	50
Fe^{55}	1
Ga^{72}	10
Ge^{71}	50
H^{3}(HTO or H_2O)	250
I^{126}	10
In^{114}	1
Ir^{192}	10
K^{42}	10
La^{140}	10
Mn^{52}	1
Mn^{54}	50
Mo^{99}	10
Na^{22}	10
Na^{24}	10
Nb^{95}	10
Ni^{59}	1
Ni^{65}	1
P^{32}	10
$Pd^{109}+Rh^{109}$	50
Pd^{109}	10
Pm^{147}	10
Po^{210}	0.1
Pr^{143}	10
Pu^{239}	1
Ra^{226}	0.1
Rb^{86}	10
Re^{183}	10
Rh^{105}	10
$Ru^{106}+Rh^{106}$	1
S^{35}	50
Sb^{124}	1
Sc^{46}	1
Sm^{153}	10
Sn^{113}	10
Sr^{89}	1
$Sr^{90}+Y^{90}$	0.1
Ta^{182}	10
Tc^{96}	1
Te^{99}	1
Te^{127}	10
Te^{129}	1
Th (natural)	50
Tl^{204}	50
Tritium. See H^3	
U (natural)	50
U^{235}	1
U^{235}–U^{238}	50
V^{48}	1
W^{185}	10
Y^{91}	1
Zn^{65}	10
Unidentified radioactive materials or any of the above in unknown mixtures	0.1

NOTE: For purposes of §§ 20.203 and 20.304, where there is involved a combination of isotopes in known amounts the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i. e., "unity").

EXAMPLE: For purposes of § 20.304, if a particular batch contains 2,000 μc of Au^{198} and 25,000 μc of C^{14}, it may also include not more than 3,000 μc of I^{131}. This limit was determined as follows:

$$\frac{2{,}000\ \mu c\ Au^{198}}{10{,}000\ \mu c}+\frac{25{,}000\ \mu c\ C^{14}}{50{,}000\ \mu c}+\frac{3{,}000\ \mu c\ I^{131}}{10{,}000\ \mu c}=1$$

The denominator in each of the above ratios was obtained by multiplying the figure in the table by 1000 as provided in § 20.304.

NOTE: The record keeping and reporting requirements contained herein have been approved by the Bureau of the Budget in accordance with the Federal Reports Act of 1942.

Dated at Washington, D. C., this 16th day of January 1957.

For the Atomic Energy Commission,

K. E. FIELDS,
General Manager.

[F. R. Doc. 57-511; Filed, Jan. 25, 1957; 12:30 p. m.]

APPENDIX K

RADIOACTIVE WASTE DISPOSAL REQUEST

Date_____ Location of waste_____

Approximate volume
and composition_____

Curie activity of each
radioactive element_____

External radiation_____

Container to be
saved or destroyed_____

Disposal requested by_____

FINAL DISPOSAL

Place of disposal_____

Remarks_____

_____

_____

_____

_____ _____

Date Radiation Safety Officer